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CALIFORNIA ENERGY FLOW IN 1978

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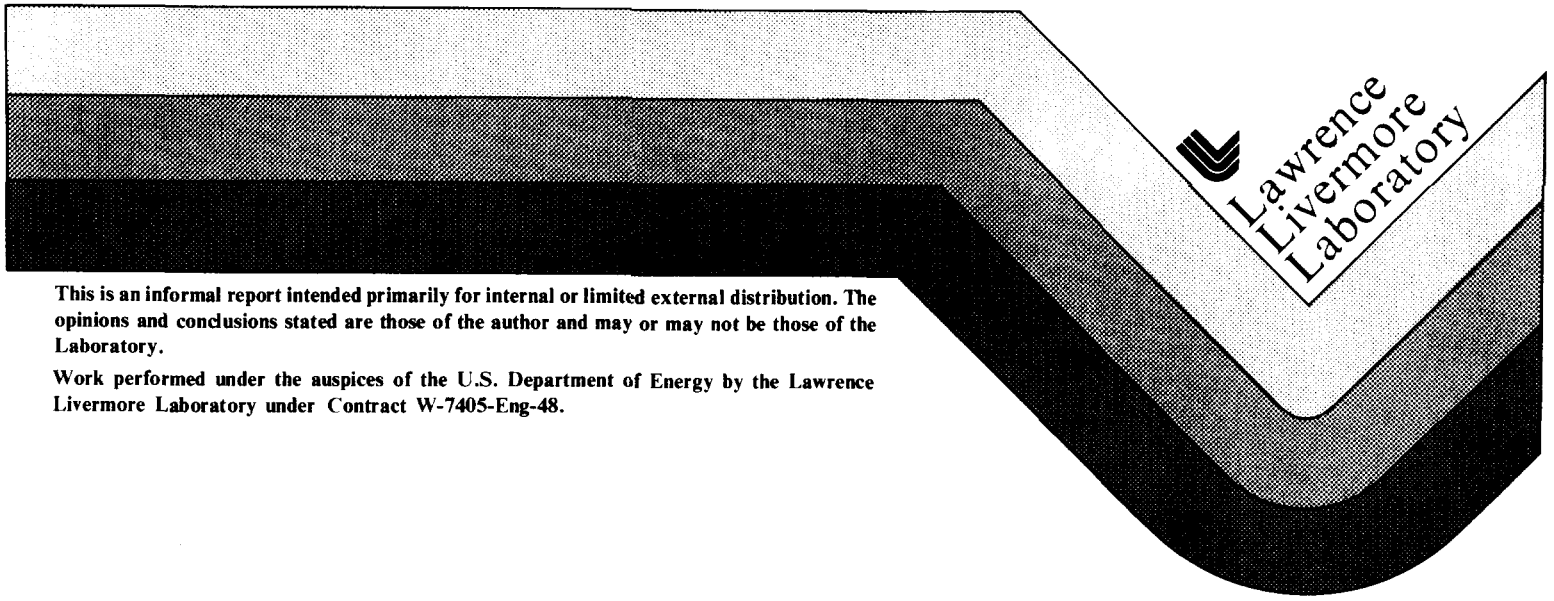

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CALIFORNIA ENERGY FLOW IN 1978

Abstract

In 1978 California's total energy use was very close to that of 1977. All forms of transportation consumed 40% of all energy used as contrasted to 26% for the nation as a whole for the same year. Compared to 1977, California's use of hydroelectric power increased three-fold as the direct result of the end of the 1976-77 drought. Oil, gas and electricity usage changed by small measure, +1.6%, -5.8% and +3.6%, respectively. Oil and gas freed by the increased hydroelectric potential was used by other end-use sectors in the state with transportation taking the largest share. Consumption in that sector increased by approximately 11%.

A conspicuous change in 1978 was the new mix of crude oil sources. Domestic California production was essentially stable at 19% of the total; foreign imports chiefly from Indonesia fell 50%; interstate shipments chiefly from Alaskan North Slope more than doubled. Natural gas supply sources and uses were similar to those of 1977. Industrial use of natural gas appears to have fallen. There is some indication of fuel switching to fuel oils, relocation of industry to other states and conservation in response to escalated fuel prices. Coal continues to be an insignificant fuel in California. Geothermal contributed less than 2% to total transmitted electricity. The comparable figure for nuclear energy is 4% and for imported power from other states, 20%.

Introduction

Energy flow diagrams are useful devices to compare supply and end use of energy for a state, region or country. Members of the Energy and Resource Planning Group at the Lawrence Livermore Laboratory have prepared California energy flow diagrams for 1974, 1976 and 1977.[1,2,3] In preparing the 1978 California energy flow chart, the same data sources and conventions have been used to assure uniformity. Efficiencies were assumed in order to calculate "rejected energy." Arguments for the percent efficiencies used are given in Reference 2. Briefly, fossil power plants, hydroelectric, geothermal and nuclear sources are associated with 33%, 90%, 19% and 33% efficiencies, respectively. In transportation 25% efficiency is assumed corresponding to the approximate efficiency of the internal combustion engine. 75% and 70% were arbitrarily assumed in the industrial and residential/commercial end use sectors respectively.

Source of Data

Tables 1 and 2 list the data sources used in preparation of the 1978 energy flow diagram. DOE Energy Data Reports and CEC Quarterly Fuel and Energy Summaries provided most of the data. In 1978 CEC Quarterly Summaries eliminated individual utility data and reported statewide totals only.

Compilation of Data

Residential, commercial and firm industrial customers, all with highest priority among utility customers have been combined and separated from interruptible industrial.

The "Non-Energy" category is described in Table 2. The major portion of this records the quantity of petroleum asphalt used. Natural gas used in ammonia preparation is also included.

Imported electrical power transmitted across state boundaries is 84 x 10^{12} Btu from hydro sources and 37 x 10^{12} Btu from coal source (Figure 1). The transmitted electrical power from imported hydro sources was derived from net exchange in interstate transfers; power from out-of-state coal-fired plants is recorded separately by the CEC. Out-of-state

Table 1.

Data Sources for California Supply

Production	
Crude Oil including Federal Offshore and Lease Condensate	Ref. (4)
Associated and nonassociated natural gas	Ref. (4)
Electrical Generation (hydro, nuclear, oil, gas, geothermal)	Ref. (5), Tables A, B, and C.
Imports	
Natural Gas	
Foreign	Ref. (5), Table D
Domestic	Ref. (5), Table A
Crude Oil (foreign and domestic)	Ref. (6), Table 13
Oil Products (foreign & domestic)	Ref. (5), Table M
Coal	Ref. (7), Table IV
Electrical Power	Ref. (5), Table A
Exports	
Oil Products (foreign & domestic)	Ref. (5), Table N

Table 2.

Data Sources for California End Uses

Net Storage and Field Use	
Natural Gas	Ref. (8), Tables 4 and 6
Transportation	
Crude Oil	
Refinery output of gasoline aviation fuel and jet fuels	Ref. (5), Table K
Taxable diesel fuel (i.e., for public highways	Ref. (9), Table J3, p. 122
Rail diesel	Ref. (10), Table 10
Vessel bunkering	Ref. (10), Table 11
Exports of gasoline, jet fuel and Bunker C.	Ref. (5), Table N
Military use	Ref. (10), Table 12
Natural gas	
Lost or unaccounted for (transmission & pipeline) from gas utilities	Ref. (5), Table D

Non-Energy Applications

Crude oil and LPG	
Asphalt	Ref. (11), Table 5
Synthetic rubber and other miscellaneous petrochemical uses	Ref. (12), Tables 7 and 8
Waxes, lubricating oils, medicinal uses, cleaning	Ref. (2)
Natural Gas	
Fertilizer	Ref. (13)

Residential and Small Commercial

Natural Gas	Ref. (5), Table D
Crude Oil and other oils LPG (heating)	Ref. (12), Table 3
Fuel oil and kerosine	Ref. (10), Table 5
Residual and distillate oil (heating)	Ref. (10), Tables 6 and 7
Miscellaneous "off highway" diesel	Ref. (10), Table 14
Electricity	Ref. (5), Table C

Industrial, Government, Agriculture etc.

Natural gas	Ref. (5), Table D
Coal	Ref. (7), Table IV
Electricity	Ref. (5), Table C
Crude oil	By difference

coal fired plants are at Four Corners, Farmington, New Mexico; Navaho Plant at Page, Arizona; and the Mohave Plant, Nevada. Out-of-state hydroelectric power is from the Pacific Northwest (Bonneville Power Administration) and the Southwest (principally Hoover and Davis Dams on the Colorado River).

Conversion from fuel quantities to Btu was made using U. S. Bureau of Mines factors given in the Appendix.

Comparison with Past Years

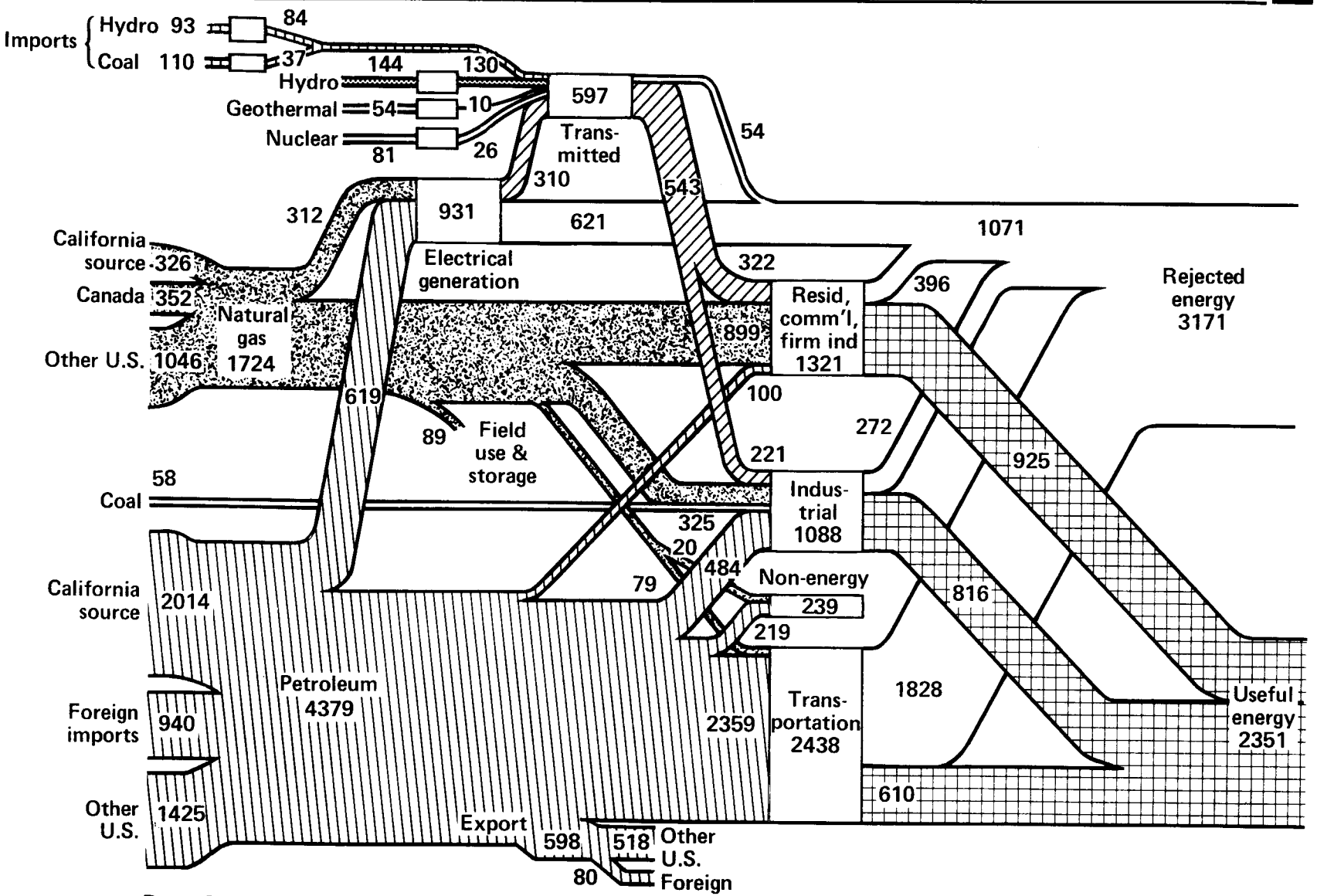
The single most noteworthy feature of the total energy consumption in California in 1978 (Figure 1) is the fact that it differs insignificantly from the previous year (Figure 2). Although the Iranian revolution and associated oil cut-off was initiated in October 1978, the disruption had no impact until the following May. The trans-Atlantic transit takes about 45 days and a near normal situation prevailed in the U.S. for several months following the Iranian cutbacks in oil production.. The total energy demand in California apparently leveled off after steady increases in the past for all but recession years. By contrast in the same time frame (1977-1978) the U. S. consumption rose 2.2% from 76.4 quads (10^{15} Btu to 78.2 quads.[14]

In 1978 California was still feeling the indirect effects of a severe drought which affected energy usage. The drought affected the northern portion of the state more than the southern (Figure 3). Indirect effects in 1977 took the form of conservation of many basic necessities (Figure 4) and affected both northern and southern halves of the state. It has been described as a "conservation ethic" which prevailed during and after the period of acute water shortage.[15]

The drought ended when seasonal rains began to refill reservoirs in the fall-winter of 1977. California hydroelectric power as a consequence increased by almost threefold in 1978 (Figures 1 and 2). Imported hydroelectric power also increased dramatically between 1977 and 1978 but did not equal the 1976 values of 126 x 10^{12} Btu.[2] Natural gas and oil usage for power generation fell 18% and 23%, respectively. Total transmitted electrical energy showed a modest increase on the order of 4% (Table 3).

Another significant difference between 1978 energy supply and that of other years (Table 3) is the amount of foreign oil coming into California refineries. In 1978 it dropped 50%. Imports from Indonesia, California's largest supplier, fell 15%; and those from Arab countries fell 78%. By contrast, California production remained about the same and

CALIFORNIA ENERGY FLOW - 1978
TOTAL ENERGY CONSUMPTION 6050 X 10^{12} Btu



Data: California Energy Commission; California Division of Oil and Gas, DOE/EIA

Figure 1

CALIFORNIA ENERGY FLOW – 1977 (10^{12} Btu)

Total Energy Consumption 6000 X 10^{12} Btu

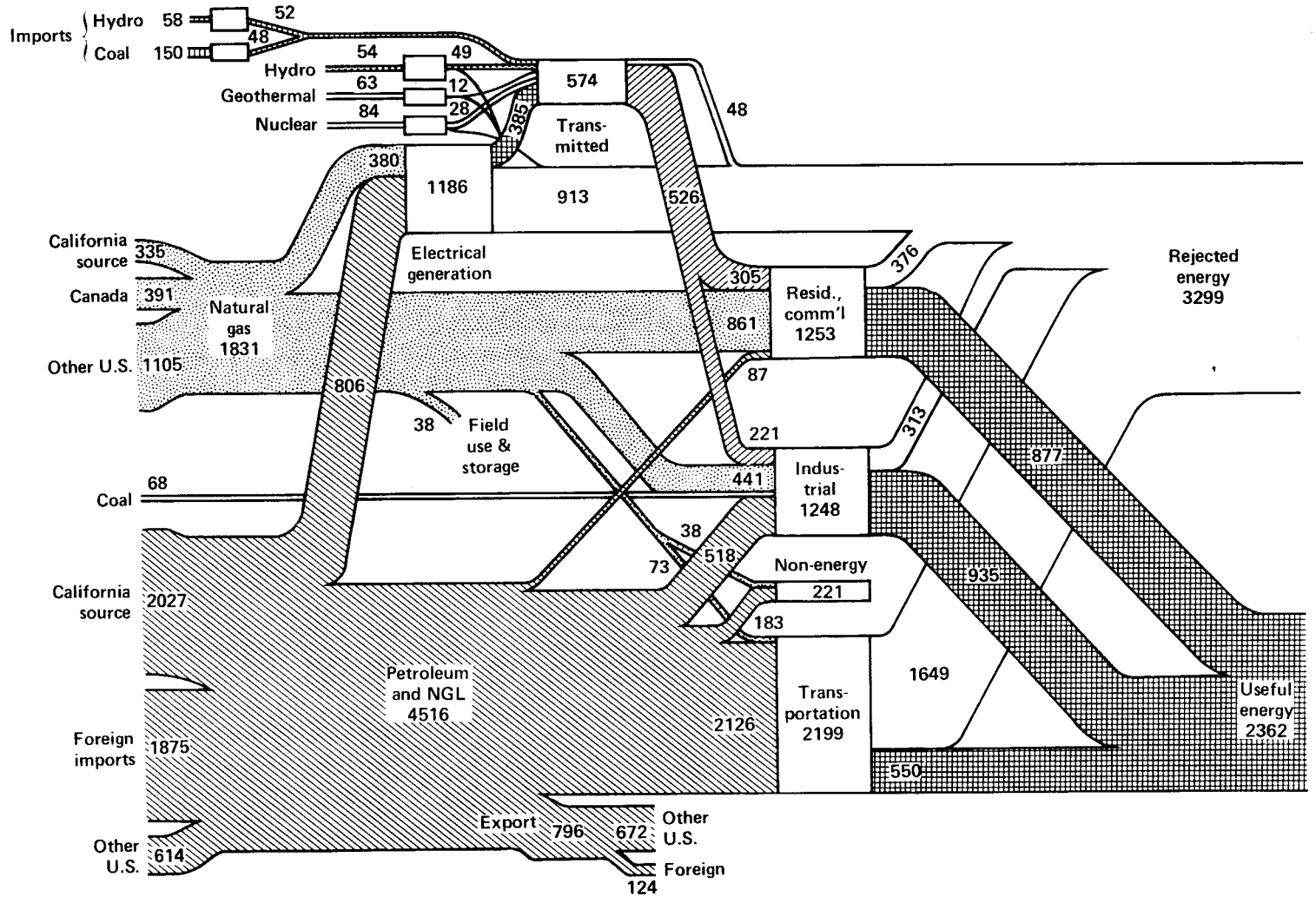


Figure 2

(Reference 3)

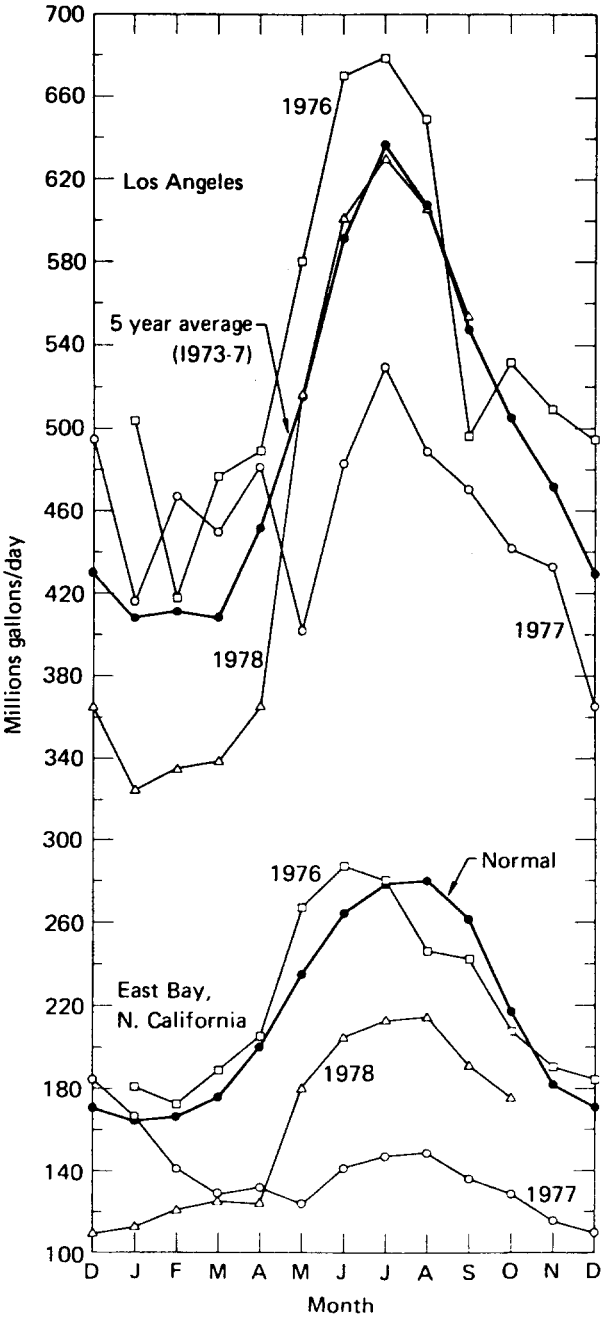


Figure 3

Water consumption for Los Angeles and the East Bay in Northern California (Ref. 15)

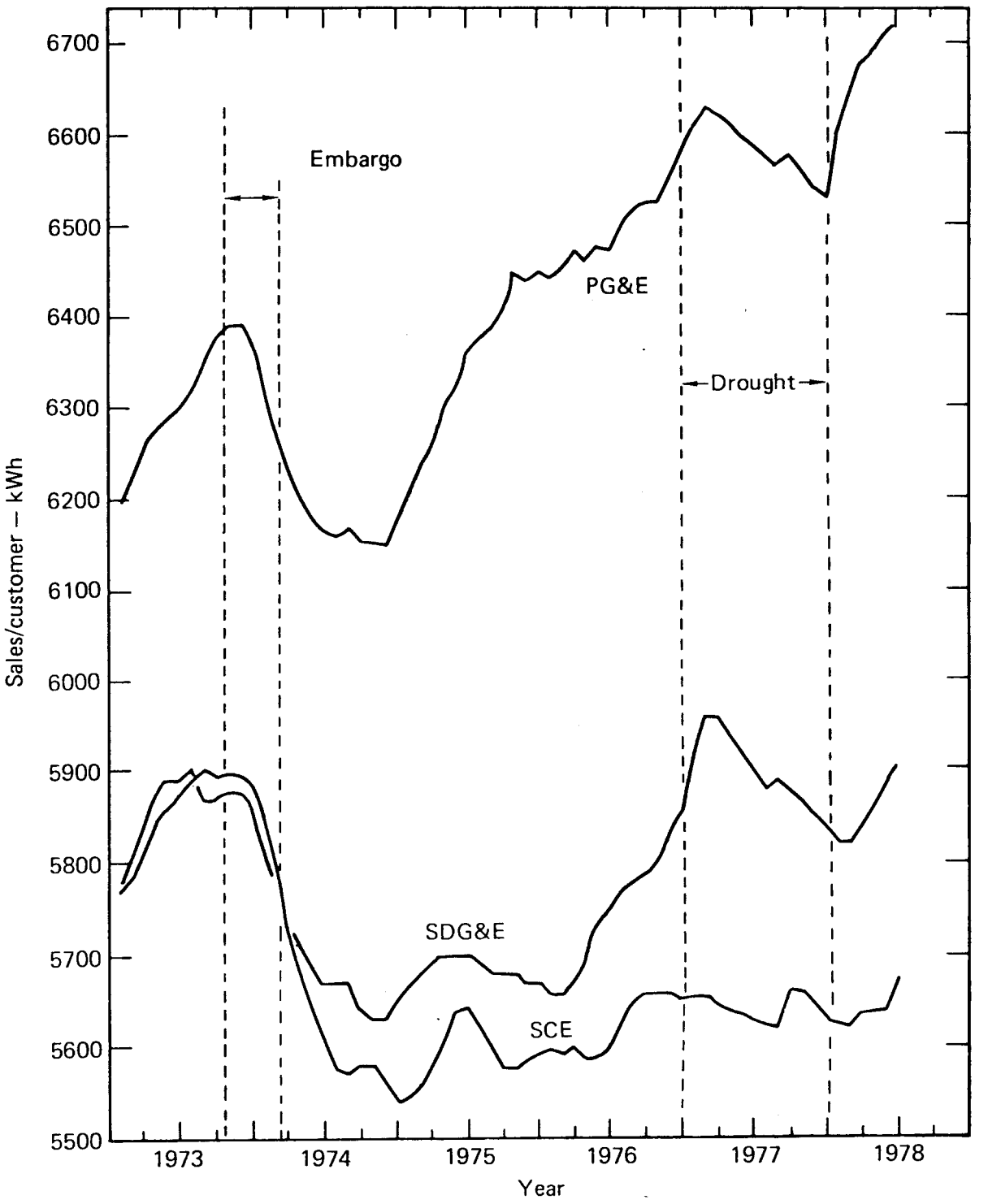


Figure 4

California residential electrical use (climatically adjusted) (Ref. 15)

Table 3.

Comparison of 1978 and 1977 Energy Use in California

	1976	1977	1978	CHANGE - 1977 vs. 1978
			10^{12} Btu	
Natural Gas	1844	1831	1724	-5.8%
Crude Oil	3886	4516	4379	-3%
California Source	1921	2027	2014	-1%
Foreign Imports	1606	1875	940	-49.9%
Other U. S.	359	614	1425	+132.1%
Domestic/Foreign Exports	630	796	598	-25%
Net Use	3256	3720	3781	+1.6%
Electricity				
Imports*	158	100	121	+21%
Imports**	267	208	203	-2.4%
Hydroelectric	94	54	144	+167%
Geothermal and Other	79	63	54	-14%
Nuclear	51	84	81	-4%
Gas	358	380	312	-18%
Oil	619	806	619	-23%
Total Fuel	1413	1595	1413	-11.4%
Total Transmitted Energy	577	574	597	+3.6%
Residential/commercial/firm industrial	1406	1253	1321	+5.4%
Industrial	1162	1248	1088	-12.8%
Nonenergy	222	221	239	+8.1%
Transportation	2004	2199	2438	+10.9%

* As imported MW·h (not energy-fuel equivalents)

**As hydroelectric power or coal before conversion to electricity

imports from other states, primarily Alaska, increased by 132%. These imports came principally to the ARCO refinery at Carson, the Chevron refinery at Richmond, and the Exxon refinery at Benicia. All together, California oil demand remained on a par with 1977. This occurred because the oil displaced by increased hydropower was used by the transportation industry. Here usage increased 11% over 1979. Transportation includes motor and aviation gasoline, diesel, military and bunkering fuels.

Demand for natural gas in the state decreased somewhat in 1978. There was a cut-back from all sources -- domestic, Canadian and interstate (Figure 1). The biggest drop in consumption was recorded by industrial users with interruptible service. In some instances this was a reflection on fuel switching to #5 fuel oil and #2 distillate. In others it was due to relocation, price driven conservation or reclassification of customers to other (higher) priorities and utility schedules. In 1978 the cost of natural gas from all major utilities substantially exceeded the spot fuel oil prices on the Pacific Coast (15).

Overall the industrial sector used 13% less energy (oil, gas and electricity) in 1978 than in 1977. The high priority users (residential, commerical and then industrial) increased their combined usage slightly. The increase occurred despite savings accrued from the conservation ethic born of the drought and conservation fostered by the inverted rate structures.* The novel rate structures were fully implemented by all public utilities in the state by July 1977. Between November 1975 and July 1977 they were transitional between traditional "declining" blocks where increased usage commanded smaller unit costs, and the inverted structure.

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*rate structures set up so that unit costs of the fuel increase with increasing usage.

Comparision with the U.S. Data

Reference to Figure 1 and 5 will verify the large difference in energy consumption patterns between California and the nation as a whole. California is essentially oil-dependent as some 72% of energy used is derived from that one source. By contrast for the U.S. the percent is about fifty-one. (16) By the same measure coal is an incidental fuel in California. It supplies almost 20% of the nation's 1978 energy. These differences are reflections on the West Coast's readily available mix of fossil fuels. In addition to an indigenous oil and gas industry, in recent years there has been an ample supply of both Alaskan and Indonesian crude oils. The contribution of natural gas to energy supplies in California - ∿ 28% - is about the same as that in the

U.S. ENERGY FLOW – 1978

(PRIMARY RESOURCE CONSUMPTION 78.0 QUADS)

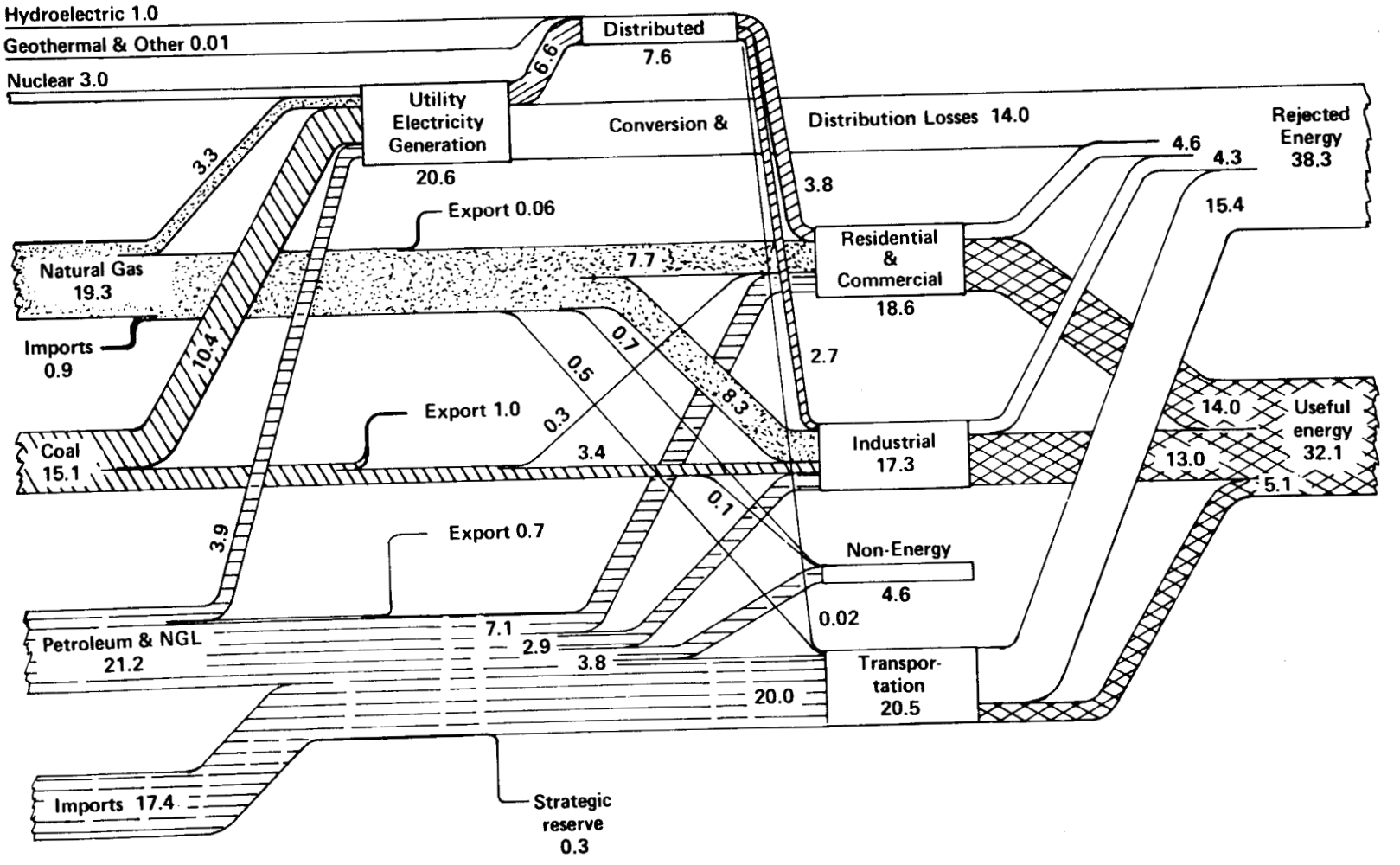

Figure 5

(Reference 16)

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(14) Monthly Energy Review DOE/EIA 0035/80, 1980.

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APPENDIX: CONVERSION UNITS

Energy Source	Conversion factor, 10^6 Btu
Electricity	3.415 per MW·h
Coal	22.8 per short ton
Natural gas	1.05 per MCF
LPG	4.01 per barrel
Crude oil	5.80 per barrel
Fuel oil	
Residual	6.287 per barrel
Distillate, including diesel	5.825 per barrel
Gasoline and aviation fuel	5.248 per barrel
Kerosene	5.67 per barrel
Asphalt	6.636 per barrel
Road oil	6.636 per barrel
Synthetic rubber and miscellaneous	
LPG products	4.01 per barrel

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